Assessment of the Eel
(Anguilla rostrata) Population
in Nova Scotia, 1981

by

Susan J. Hutchison

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Abstract

A provincial survey of eel stocks in Nova Scotia has been completed for the year 1981. A summary of data on population densities, age-length-weight distributions, feeding habits, and mercury content is presented. Populations of younger, larger eels were found to exist in the North Shore area. Richmond, South Shore, Eastern Shore and Southwestern Nova were found to have, in order, decreasing average sizes of eels and increasing average ages. Studies of food indicate a preference for mummichogs in the North Shore area, yellow perch on the South Shore and gaspereau eggs in Richmond. All areas were characterized by a range of food items including eels, insects, and other non-fish organisms. Ageing techniques employing otoliths in alizarine red stain allowed for a large number of otoliths to be examined. Total mercury content for all eels was found to be 0.41 $\pm$ .01 ppm - within the Canadian - U.S. allowable level for marketable fish.

Introduction

Eel (Anguilla rostrata) populations in Nova Scotia have enjoyed limited fishing pressures in most areas. With the exception of the South Shore and Southwestern Nova, eel sales have been limited to local markets. Demand for eels in Nova Scotian markets is small, owing to the relatively low percentage of the population interested in consuming this European delicacy.

Value of the eel fishery promises to escalate substantially in the next few years. Sources of eel consumed on foreign markets are limited. Demand, however, continues to grow. Sumptuous eel is eaten in large quantities throughout Europe and is a delicacy closely associated with Weinachten in December. Few Weinachten Festen (Christmas feasts) are complete without the familiar scent of smoked or jellied eel.

Bringing the eels from their natural habitat to table product is the substance of the eel fishery. Eels are presently being taken by baited pot throughout the spring and summer months. They are captured in flumes as they migrate downstream in the spring. Some hibernate in the muddy river and lake bottoms and return to estuarine areas to feed during the summer. Others continue to migrate further upstream and are captured

in the lakes in baited pots. Finally, they are trapped in weirs in the fall months as mature eels initiating their swim to the Sargasso Sea.

Seaward migration of silver eels in the fall of the year is of significant economic importance. Silver eels command a high market price, as compared with less mature yellow eels, due to their high fat content. Success of the silver eel to migrate downstream and continue on its long voyage back to the Sargasso Sea to spawn is also of great importance. Their fecundity insures the abundance of young which will become future populations. To date there are no upper size restrictions on the silver eel. Consequently, the largest, most productive eels are often captured before they are able to complete their life cycle.

The percentage of migrating eels, which are bound for the sea to reproduce, is a function of the river system. Factors controlling maturation in natural environments are not fully understood. Whether the young eel returns to the same area its parent left is also unknown. Knowledge of the size and dynamics of existing populations may help to understand and predict future populations. Management of these populations is the key to maintaining a successful fishery. Uncontrolled growth of the fishery promises to nullify the longevity of the eel populations.

Use of the enclosed information in conjunction with previous and following reports, in the establishment of active management practices, promises to avoid situations such as those present in the Baltic. Svärdson (1976) reported that the best fishery in Sweden, on the southeast coast, had its peak in the late 1930's. During the 1960's, the yield dropped at an alarming rate. The catch is now about 500 tons, for example, half of the best yield 30 years ago. Svärdson suggests this downward trend indicates a gradual decline of the eel population. The general picture emerging from official statistics is consistent with the interpretation that the various fisheries produced higher yields with increasing effort up to a certain turning point.

Initial investigations on the migration of juvenile eels (glass eels) into Nova Scotian waters have been conducted (Hutchison, 1981). The present report is concerned with the second phase of eel life in local waters. Eel populations in twenty-five areas have been sampled. Catch statistics for each area have been recorded. The samples have been analyzed for length, weight, age and stomach contents of the individual eels. Length and age percentages for the total Nova Scotia sample have also been produced and discussed. Mercury content of meat samples have been analyzed.

Results have been discussed by dividing the province into five regions. Comparison of these areas lends information regarding the most productive area for eels in Nova Scotia.

It was the intention of this study to complete a stock assessment of the provincial eel population. Future fishery practices may be based in part upon the information provided herein.

Materials and Methods

Eels were captured in baited trap nets in varied locations throughout Nova Scotia. Herring proved to be by far the best bait for attracting eels. Waters were fished until 30 eels were captured or the area became too expensive timewise to justify continued efforts. A maximum of four nights per area was established. Number of nets fished, number of eels captured per day, pH, and temperature readings were recorded for each location. Samples were bagged, labelled and frozen for laboratory analysis.

In the laboratory, samples were thawed and arranged in labelled trays. Each eel was then weighed on a Metler 2000 balance and measured for length; the stomach was dissected and retained; the otoliths were dissected out and retained; and a meat sample was taken

for chemical analysis. Any intestinal parasites were retained. Otoliths were stored in 70% alcohol, and stomachs and parasites in Formalyn (40% formaldehyde).

Otoliths were then taken out of the alcohol and soaked in 2% potassium chloride to remove the cartilaginous layer which causes the otolith to be opaque. Next, they were immersed in a working solution of alizarine red (Humason, 1972) and allowed to remain until the stain had penetrated the otolith. Otoliths were then examined at 12.5 magnification in polarized light under a dissecting scope. Observations were facilitated by immersing the otoliths in glycerine. Otoliths were aged, a sample photographed, and retained in glycerine.

Stomachs were dissected, the contents identified and recorded per individual. All material was then discarded.

Mercury analysis of the meat samples was completed as per Armstrong and Uthe (1971) and results recorded.[1]

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[1]Mercury analysis was completed by and with the compliments of Dr. Michael W. Gilgan of the Regional Inspection and Technology Lab., Scotia-Fundy Regional Laboratory, Fisheries and Oceans, Halifax, Nova Scotia.

Results and Discussion

Locations:

Locations were chosen at random and varied from estuarine tidal areas to freshwater lakes and rivers. In some instances, one system was investigated by fishing both harbour and inland lakes (example Indian River System). Figure 1 and Table 1 serve to indicate the distribution of sites and their exact locations. Catch statistics (Table 2) were provided for each site and all sites were grouped into 5 areas. Areas are described in Table 3 and Figure 2. Groupong of locations into areas facilitated analysis and discussion of results and makes regional comparisons possible.

Figure 1 location of waters sampled for eels. Key to numbers is as per Table 1.

Table 1 Location of waters sampled for eels

no	location	county	latitude N	longitude W
1	Argyle Head	Yarmouth	43°50'	65°51'
2	Beaverdam Lake	Shelburne	43°40'	65°25'
3	Black Lake	Cumberland	45°42'	63°55'
4	Cap La Ronde	Richmond	45°34'	60°54'
5	Clam Harbour	Halifax	44°43'	62°52'
6	Eds Pond	Yarmouth	43°50'	65°51'
7	Eel Lake	Digby	44°14'	66°03'
8	Gavels Lake	Yarmouth	43°55'	65°56'
9	Grand Lake	Richmond	45°12'	61°03'
10	Herring Cove Lake	Queens	44°08'	64°43'
11	Indian Harbour	Guysborough	45°06'	61°50'
12	Indian Harbour Lake	Guysborough	45°07'	61°52'
13	Inhabitants	Richmond	45°40'	61°15'
14	Lake Ainslie	Inverness	46°10'	61°10'
15	Lake Charlotte	Halifax	44°47'	62°56'
16	Loch Lomond	Richmond	45°45'	60°35'
17	Marble Mountain	Inverness	45°49'	61°03'
18	Margaree Harbour	Inverness	46°26'	61°06'
19	Merigomish Harbour	Pictou	45°37'	62°30'
20	Pleasantville	Lunenburg	44°20'	64°26'
21	Pomquet Harbour	Antigonish	45°37'	61°48'
22	Pondville	Richmond	45°32'	60°39'
23	Port Royal Harbour	Richmond	45°31'	61°05'
24	Randals Lake	Yarmouth	43°51'	65°51'
25	River John	Pictou	45°45'	63°03'
26	Wentzells Lake	Lunenburg	44°29'	64°37'

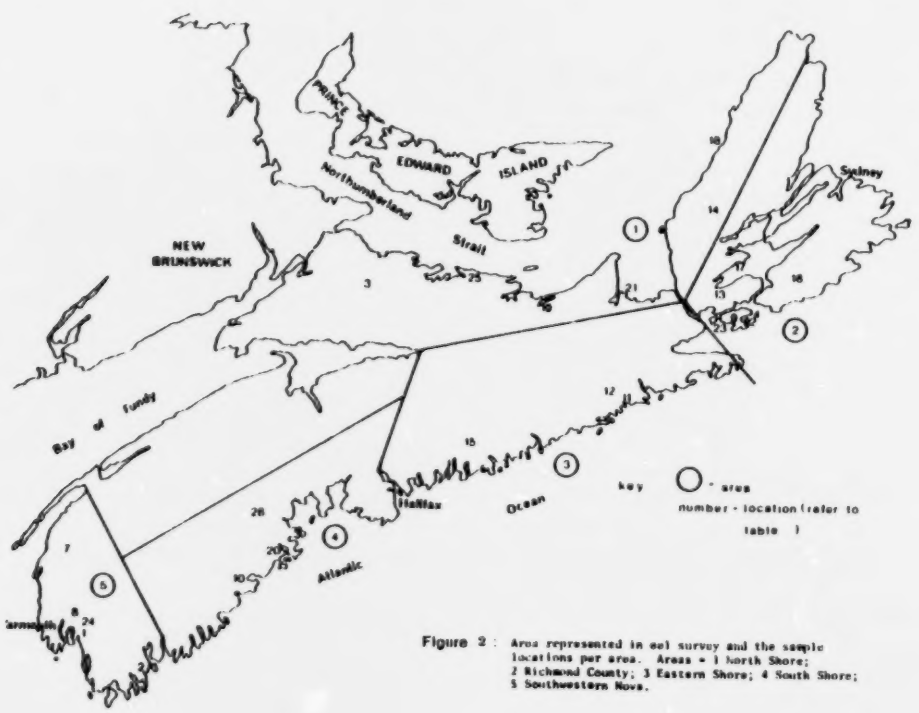


Figure 2 : Area represented in eel survey and the sample locations per area. Areas = 1 North Shore; 2 Richmond County; 3 Eastern Shore; 4 South Shore; 5 Southwestern Nova.

Table . Catch per unit effort (eels/pot) is given per day (number of eels per pot) and location (average number of eels per pot per location) for areas sampled. pH and temperature (°C) are included where available.

no	location	date	no pots	no eels	no eels/pot	avg no eels/pot location	pH	°C
1	Argyle Head	5/06-6/11	elver trap	12	n/a	n/a		
2	Beaverdam Lake	5/26	10	3	0.3			
		5/27	10	3	0.3			
		5/28	10	28	2.8	1.1		
3	Black Lake	8/18	12	2	0.2	0.2	5.9	23
4	Cap La Ronde	6/17	10	11	1.1			
		6/18	10	20	2.0	1.6		
5	Clam Harbour	7/22	11	27	2.5	2.5		
6	Eds Pond	5/19	20	50	2.5	2.5		
7	Eel Lake	5/20	9	6	0.7			
		5/21	9	5	0.6	0.6		
8	Gavels Lake	5/13	6	25	4.2			
		5/14	6	7	1.2			
		5/15	6	7	1.2			
		5/17	6	40	6.7	3.3		
9	Grand Lake	6/08	12	0	0.0			
		6/09	12	4	0.3			
		6/13	12	8	0.7			
		6/14	12	20	1.7	0.7		
10	Herring Cove Lake	8/06	10	1	0.1			
		8/07	10	69	6.9	3.5		
11	Indian Harbour	7/20	11	245	22.3	22.3		
12	Indian Harbour Lake	7/21	11	14	1.3			
		7/22	11	15	1.4	1.3		
13	Inhabitants River	6/29	6	21	3.5			
		6/30	6	9	1.5	2.5		
14	Lake Ainslie	8/15	11	7	0.6	0.6		
15	Lake Charlotte	7/24	11	40	3.6	3.6		
16	Loch Lomond	6/27	13	60	4.6	4.6		
17	Marble Mountain	6/22	10	4	0.4			
		6/24	10	22	2.2			
		6/25	10	2	0.2	0.9		
18	Margaree Harbour	8/14	12	17	1.4	1.4	7.5	15.5
19	Merigomish Harbour	8/11	10	20	2.0		7.4	20.0
		8/12	10	46	4.6	3.3		
20	Pleasantville	8/04	11	160	14.6	14.6		
21	Pomquet Harbour	8/13	11	40	3.6	3.6	7.0	19.5
22	Pondville	6/15	10	100	10.0			
		6/16	10	60	6.0	8.0		
23	Port Royal Harbour	6/19	6	10	1.7			
		6/20	9	19	2.1			
		6/21	9	12	1.3	1.7		
24	Randals Lake	5/12	6	40	6.7			
		5/17	6	24	4.0	5.3		
25	River John	8/16	12	19	1.6		7.65	19.0
		8/17	12	7	0.6	1.1		
26	Wentzells Lake	8/05	11	29	2.6	2.6		

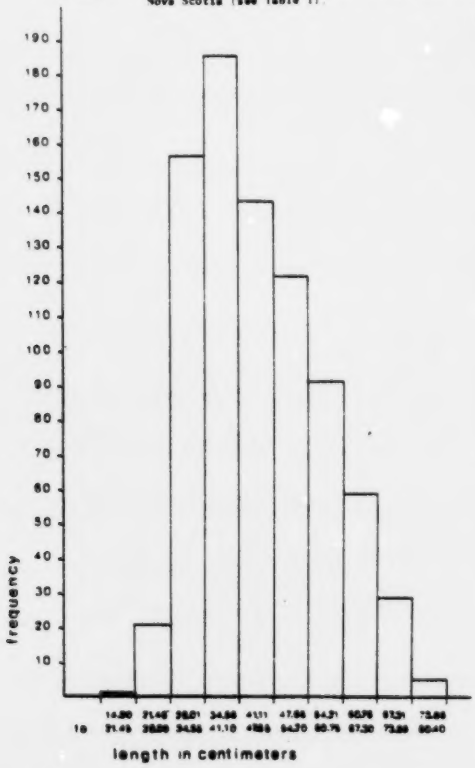
Table 3 List of locations per area assessed and the number of eels per area.

no	area	n	locations
I	North Shore	6	Black Lake Lake Ainslie Margaree Harbour Merigomish Harbour Pomquet Harbour River John
	number of eels = 130		
II	Richmond	7	Cap La Ronde Grand Lake Inhabitants Loch Lomond Marble Mountain Pondville Port Royal Harbour
	number of eels = 198		
III	Eastern Shore	3	Clam Harbour Indian Harbour Indian Harbour Lake Lake Charlotte
	number of eels = 125		
IV	South Shore	3	Herring Cove Lake Pleasantville Wentzells Lake
	number of eels = 109		
V	Southwestern Nova	6	Argyle Head Beaverdam Lake Eds Pond Eel Lake Gavels Lake Randals Lake
	number of eels = 216		

Population Densities:

Length distribution (Figure 3) of eels captured in baited traps show a strong positive skew, thereby suggesting that the nets collect a random sample of the populations except for the youngest ages. It is assumed, therefore, that the catch per unit effort is proportional to the density of the population except for the young eels. It follows then that the figures for catch per unit effort given in Table 2 are taken to represent different population densities.

Figure 3 Length frequency histogram of 778 eels from all areas sampled in Nova Scotia (see Table 1).



Catch per unit effort:

Catch per unit of effort figures in Table 2 show the greatest number of eels per night was recorded in Indian Harbour at 22.3 per trap. Pleasantville recorded a 14.6 per trap catch. Relatively high values of more than

4 eels were also recorded in Loch Lomond and Pondville, both in close proximity to Pleasantville. All other lakes and estuaries were described by a catch of under 4 eels per trap. In the case where lakes at different points on the same river system were sampled, the catch per unit effort decreased markedly with distance from the sea. Indian Harbour and Indian Harbour Lake values are an example of this observation.

Catch values in Nova Scotia are similar to those obtained by Moriarty (1979) for yellow eels in Ireland. As in Ireland, population densities, measured as catch per unit of effort, were found to be low in most of the freshwater lakes, but high in rivers and estuaries. This is an indication of the slow speed of migration from estuarine to head waters in river systems.

Feeding pressures and other factors affecting upstream migration appear to be weak in several local river systems. One would expect that the headwaters are productive enough to support a larger eel population. Stocking of inland waters with elvers cultured over a summer period may serve to increase their populations. Inland waters tend to produce a greater percentage of females. Females are larger than males; therefore, increased productivity in higher waters would be very desirable from a fishery perspective.

In lakes, zones described by depths of less than 5 m proved the most productive fishing areas. Weed growth, submerged vegetation, and areas of muddy bottoms were also associated with regions of high fish catches.

Age, Length, Weight Distributions:

Analyses of mean age, length and weight relationships for the five areas show a general decrease in average length and weight with an increase in mean age as one progresses from the North Shore around Cape Breton toward the southwestern end of Nova Scotia. Only the South Shore provides an exception to this trend exhibiting a population of eels similar, yet older, to that found in the south of Cape Breton.

Age, length and weight distributions are recorded in Tables 4, 5 and 6 respectively. Age, length and weight distributions are recorded in Figures 4, 5 and 6, respectively. Mean values for the total population are also included in these graphs.

Results indicate the most commercially desirable population is found along the North Shore. Warmer waters, shallow estuarine areas and abundant food sources result in a younger population of larger eels. In this environment, eels grow to a larger size faster and will replenish themselves more rapidly in response to fishing effort on

the North Shore than in other areas.

Richmond County and the South Shore are second with respect to productivity. Eel populations are exploited in both regions. The Eastern Shore has a large population of smaller eels. However, the region is represented by only three sites. Larger eels have been caught on a regular basis in this area in the past.

Southwestern Nova is characterized by populations of smaller older eels. This area is the most heavily fished in the province and accounts for approximately five times more eels taken than in all other regions with the exception of the south shore. Low numbers of larger eels may be a direct result of heavy fishing over the course of several years. If this is the case, it would serve as a good example to fishermen looking to increase effort in other areas. Proper management practices may avoid the situation common to Southwestern Nova Scotia.

Table 4 : Age Distribution (percentage of n, years)

	3-5	6-8	9-11	12-14	15-17	18-20	21-23	24-26	27-29	n	$\bar{x}$	σ
North Shore	2	30	29	29	24	10	5	-	-	129	12.16	4.28
Richmond	20	34	50	54	24	13	4	2	1	192	11.41	5.02
Eastern Shore	2	15	32	35	21	13	2	2	2	124	13.14	4.61
South Shore	6	21	21	12	21	16	8	1	-	106	13.14	5.71
Southwestern Nova	8	22	48	55	38	22	8	7	1	209	13.40	5.42
Total	38	122	180	185	128	74	19	13	4	760	12.60	5.11

Table 5: Length Distribution (percentage of n, cm)

	14.9 21.45	21.46 28.0	28.01 34.55	34.56 41.10	41.11 47.65	47.66 54.20	54.21 60.75	60.76 67.30	67.31 73.85	73.86 80.40	n	$\bar{x}$	σ
North Shore	-	-	-	4	29	36	33	23	4	1	130	53.7	8.2
Richmond	-	3	17	34	48	45	33	11	6	1	198	47.6	10.0
Eastern Shore	-	2	48	60	15	7	5	1	1	1	125	58.4	9.0
South Shore	-	2	15	21	20	15	18	12	5	1	109	47.8	12.1
Southwestern Nova	1	14	77	67	32	19	2	4	4	1	216	37.9	9.3
Total	1	21	157	186	144	122	91	59	29	5	778	45.09	9.729

Table 6: Weight Distribution (percentage of n, grams)

Area	0 50	51 100	101 150	151 200	201 250	251 300	301 350	351 400	401 500	501 600	601 700	701 800	801 900	901 1000	1001 1500	n	$\bar{x}$	σ
North Shore	-	4	13	13	22	20	11	7	13	9	8	7	1	1	-	130	340	192
Richmond	8	28	34	22	29	28	12	6	14	9	1	5	1	-	-	198	239	159
Eastern Shore	13	63	20	10	6	3	3	1	2	1	1	-	1	-	1	125	138	157
South Shore	5	31	10	12	7	7	7	5	7	8	4	4	-	1	1	109	265	231
Southwestern Nova	43	84	48	16	5	6	2	1	2	-	2	2	3	1	1	216	130	161
Total	69	210	125	73	69	64	35	20	38	27	16	18	6	3	3	778	213	193

Figure 4 Mean age in years and the standard deviation is pictured for areas 1-5: North Shore, Richmond, Eastern Shore, South Shore and Southwestern Nova, respectively, and for the total of all eels sampled.

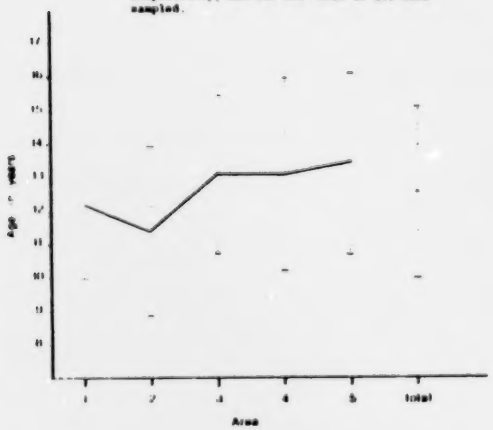
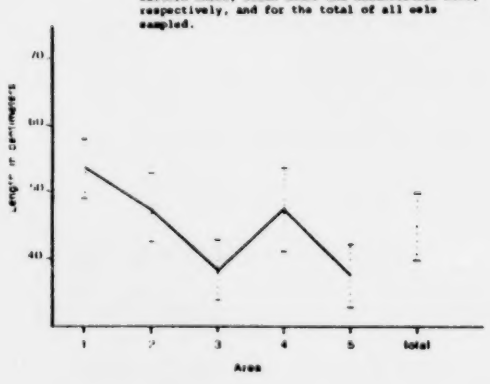


Figure 5 Mean length in years and the standard deviation is pictured for areas 1-5: North Shore, Richmond, Eastern Shore, South Shore and Southwestern Nova, respectively, and for the total of all eels sampled.



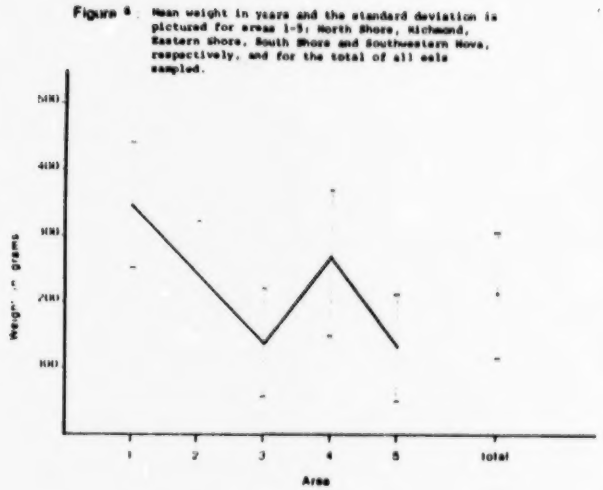


Figure 6. Mean weight in years and the standard deviation is pictured for areas 1-5; North Shore, Richmond, Eastern Shore, South Shore and Southwestern Nova, respectively, and for the total of all eels sampled.

pH:

pH values (Table 2) obtained in the northern part of Nova Scotia were found to be substantially higher, pH = 7, than values obtained in the southwestern end of the province, pH = 4.5, as described in an earlier report (Hutchison and Taylor 1980). Lower pH values are strongly associated with areas of smaller older eels. It is possible that food sources such as mummichogs are adversely affected by the low pH values. A decrease in preferred food sources would have a long-term effect of decreasing the average size of an eel at a given age. Such may be the case in Southwestern Nova Scotia.

Feeding:

Analysis of stomach contents of eels taken in all regions, Table 7, (and in areas, Table 8) indicate

that even the largest eels do not subsist on a diet exclusively comprised of fish. Insects and other organisms were identified in all sizes of eels. Of the fish species identified, mummichogs, yellow perch and gaspereau eggs were the most numerous.

Along the North Shore the predominant food source was the mummichog. Mummichogs occur most commonly in salt marsh flats, estuaries and tidal areas, especially where there is submerged or emergent vegetation. They are associated with high productivity areas which are numerous along the North Shore.

Yellow perch are a common food source for eels on the South Shore. Yellow perch are very adaptable and able to utilize a wide variety of warm to cooler habitats in large lakes, ponds, or quiet rivers. They are most abundant in the open water of lakes with moderate vegetation and clear water, and bottoms of muck to sand and gravel. Areas of this description predominate in the South Shore region and are associated with moderate to good growth.

Richmond eels were found to have a large number of gaspereau eggs in their digestive system. An indication of the food preference at a given time may be drawn from this fact. Areas in Richmond were also characterized by an abundance of mummichogs, as evidenced in their

Table 7 Results of stomach contents analysis for all eels sampled in Nova Scotia.

Location	Number of eels sampled	Eels with food		Relative frequency (%) of indicated food items by weight									
		No.	%	Banded killifish	Mummichog	Eels	Capserous eggs	Threespine stickleback	Yellow perch	Shrimp (Pandalus montagui)	Shrimp (Crangon sp.)	Terrestrial insects	Other*
Argyle Head	12	4	33.3		76.4	16.1						7.5	
Beaverdam Lake	29	12	41.4			2.7	2.3		94.4			0.6	
Black Lake	2	0	0.0										
Cap La Ronde	30	7	23.3				82.5	17.5					
Clam Harbour	25	6	24.0		98.4						1.6		
Eda Pond	50	4	8.0				32.8	67.2					
Eel Lake	11	5	45.5						100.0				
Gavels Lake	50	8	16.0				13.3		86.7				
Grand Lake	32	7	21.9		70.0			9.6		0.9	4.9	1.8	12.8
Herring Cove Lake	40	18	45.0						100.0				
Indian Harbour	40	1	2.5				100.0						
Indian Harbour Lake	20	4	20.0		4.7		95.3						
Inhabitants	21	4	19.0				100.0						
Lake Ainslie	7	2	28.6		62.2		37.8						
Lake Charlotte	40	7	17.5		27.1		72.3			0.3			0.4
Loch Lomond	33	1	3.0				100.0						
Marble Mountain	28	5	17.9				69.6			1.0	3.2		26.2
Margaree Harbour	17	3	17.6		83.9			4.8		11.3			
Merigomish Harbour	38	19	48.7	23.7	71.6								4.7
Pleasantville	40	2	5.0			4.2	95.8						
Pomquet Harbour	39	25	64.1		98.4					0.4			1.2
Pondville	20	12	60.0		85.6	4.5		3.2		0.8	4.0		1.8
Port Royal	34	18	52.9				81.5	1.8		14.9	0.1		1.8
Randals Lake	64	6	9.4		7.6		46.1		46.3				
River John	26	22	84.6	2.9	93.4				1.9	0.1	1.8		
Wentzelle Lake	29	2	6.9						100.0				
Totals	778	204	26.2										
Averages[2]	30	8	27.5	1.0	30.0	1.1	35.7	4.0	20.4	1.1	0.6	0.4	1.9
Total weight (gm) of food item				113.0	1424.8	12.5	418.7	17.4	962.6	26.5	16.6	2.2	42.1
Frequency (%) of item weight to total food weight				3.7	46.9	0.4	13.8	0.6	31.7	0.9	0.6	0.1	1.4

*Includes stickleback eggs, fourspine stickleback, ninespine stickleback, white perch, Amphipoda, crab, and Cirolana sp.

[1]Percentage of total number of eels with food to total number of eels sampled.

[2]Figures derived by totaling columns and dividing by number of locations (26). First two columns rounded to nearest whole number.

Table 8: Results of stomach contents analysis for eels sampled per area in Nova Scotia.

Area	Number of eels sampled (A)	Percentage of all eels (A)	Number of eels with food (B)	Percentage of eels (B)	Percentage of eels (B)	Computation category*	Banded killifish	Mummichog	Eels	Capserous eggs	Threespine stickleback	Yellow perch	Shrimp (Pandalus montagui)	Shrimp (Crangon sp.)	Terrestrial insects	Others**	Weight (gm) of food items per area
North Shore	130	16.7	71	34.8	54.6	I	7.8	87.6	-	1.3	0.1	0.7	0.2	0.6	-	1.7	1440.1
						II	100.0	88.5	-	4.6	1.8	1.0	10.0	56.1	-	58.6	
Richmond	198	25.4	54	26.5	27.3	I	-	26.3	1.1	57.2	3.5	-	5.8	1.6	0.1	4.2	409.6
						II		7.6	15.9	56.0	81.4	-	89.7	40.1	25.5	41.1	
Eastern Shore	125	16.1	18	8.8	14.4	I	-	35.5	-	61.9	-	-	0.1	0.5	-	0.1	131.5
						II	-	3.9	-	20.3	-	-	0.3	3.6	-	0.2	
South Shore	109	14.0	22	10.8	20.2	I	-	-	0.3	5.7	-	94.0	-	-	-	-	589.1
						II	-	-	11.9	8.1	-	57.5	-	-	-	-	
Southwestern Nova	216	27.8	39	19.1	18.1	I	-	2.0	1.4	10.1	0.5	85.6	-	-	0.3	-	466.0
						II		0.7	52.2	11.1	14.7	41.4	-	-	74.5	-	
Totals	778 (A)		204 (B)														
Weight (gm) of individual food item for entire survey							111.0	1424.8	12.5	418.7	17.4	962.5	26.5	16.6	2.2	42.1	3036.3

*Category I denotes the relative frequency (%) of each food item in a particular area; e.g. mummichogs accounted for 87.6% of the food items found in the stomachs of eels surveyed along the North Shore. Category II denotes the relative frequency (%) of a particular food item in each area; e.g. the North Shore accounted for 88.5% of the mummichogs found in eels surveyed in Nova Scotia.

**Includes stickleback eggs, fourspine stickleback, ninespine stickleback, white perch, Amphipoda, crab, and Cirolana sp.

presence in almost every trap hauled in the area.

Shrimp species were found in significant quantities as well as Banded Killifish, eels and stickleback in most regions of the province. On the Eastern Shore, gaspereau eggs were again the most abundant food source. In Southwestern Nova, young elvers were a high priority food item as well as yellow perch. In all areas no trout or salmon parr were found in the stomach contents. This indicates that eels assume a competitive rather than predator role in relation to these two species.

Ageing:

Age determination of eels is somewhat less than straightforward. Eel biologists are obliged to study the otolith for age determination as eel scale development is primarily related to the length of the eel and not its age. Age is recorded in zones etched in otolith bone. However, this record is a function of the environment and is consequently affected to a large extent by the variable weather and food conditions imposed upon the eel.

During the summer months, commonly denoted by opaque zones in the otolith, there may exist periods of low food availability and cooler temperatures. Such conditions would result in a slowing of growth and a subsequent interruption of the opaque zone by a translucent

section. Translucent sections normally denote winter periods. Reinstatement of favourable growth conditions would read as a second opaque zone on the otolith. The existence of extra growth zones, denominated as "supernumary zones" (Deedler, 1976), complicate the otolith ageing technique. The possibility of up to three supernumary zones per year exists, implying that up to two stops in summer growth may occur in a seasonal growth period (ibid.).

In addition to translucent winter and opaque summer zones, translucent supernumary zones were observed in the otoliths examined in this study. The supernumary zones usually appeared as an isolated narrow zone and could be differentiated from the true winter zone.

Techniques developed for ageing eels range from dipping the otoliths in creosote and observation in reflected light, to polishing them using a metalurgical treatment (Wiedemann Smith, 1968). The method of Wiedemann Smith produces extremely polished surfaces on which very fine lines can be observed. These lines appear to coincide solely with winter growth stops and not with supernumary stops (Deedler, 1976). However, time requirements demanded by the procedure render it unsuitable for applied fishery research purposes.

Methods necessitating the cutting of slides from the otoliths demand much time and effort. Densitometry

and photography, both of which require sectioning, have a number of advantages. Unfortunately, purchase costs of the required equipment for both methods are high.

Age determinations evaluated in this report have been facilitated by the use of alizarine red stain. Commonly associated with histological techniques, this bone stain penetrates the calcified tissue. Areas of higher calcium densities, the opaque zones, take up more stain and define themselves in contrast to the translucent areas. An outer layer, the cartilage is removed after soaking in potassium chloride (1%). Growth zones are then observed and counted under polarized light.

Otoliths are as different as individual eels. Exterior contours are landscapes in themselves and give rise to varying densities along the otolith. Clarity of zones over the entire otolith surface is sometimes obscured and must be further unmasked by rubbing the otolith over fine emery paper. Age determinations require decisions in each instance regarding actual year zones. Consistency is the key in using this method.

Techniques such as that employed here have the advantage of requiring less preparation time per otolith. Increased numbers of otoliths may, therefore, be aged. Any crudeness on behalf of the technique is amended in

numbers. The method is not without accuracy and produced acceptable results.

Mercury:

Total mercury content for 76 samples from all areas in Nova Scotia was found to be 0.41 ± .01 ppm (mean ± standard error). Levels for specific areas, Table 9, show that the highest values were recorded on the South Shore and in Southwestern Nova. Mercury content of 0.76 ± .02 and 0.65 ± .01 ppm, respectivel , exceeds the Canadian-U.S. allowable level of 0.50 ppm for marketable fish. Other areas showed lower values, all below the 0.50 ppm level: North Shore 0.12 ± .00, Richmond County 0.25 ± .01, and Eastern Shore 0.32 ± .01.

Total mercury content represents both methylmercury (MeHg) and mercury (Hg) levels in fish. It is the MeHg that is believed to be more toxic than inorganic and other mercury compounds. MeHg is believed to be the principal causative agent in the neurological diseases at Minamata and Nugata, Japan (Berglund et al., 1971).

Freeman and Horne (1972) analyzed samples from the South Shore and found total mercury content to be 0.72 + .05 ppm. Of this value 0.40 + .06 ppm represents the value of methylmercury in the total sample. The level of toxic mercury in the eels was then below the 0.50 ppm limit. Consequently, Freeman and Horne concluded that

these eels were fit for human consumption. Freeman and Horne, however, do not state whether the limit is designed for total mercury or toxic mercury estimates.

This situation may be the same for the South Shore and Southwestern Nova today. However, methylmercury values are not included in this report.

Table 9: Mercury Levels (parts per million)

	n	$\bar{x}$	σ
North Shore	14	.119	.065
Richmond	22	.248	.246
Eastern Shore	8	.302	.185
South Shore	8	.763	.367
Southwestern Nova	24	.646	.288
Total	76	.410	.339

Summary

1. Twenty-five locations were fished for eels. All eels were analyzed for length, weight, age and stomach contents. Results were grouped under five areas to facilitate regional comparison.

2. Figures for catch per unit effort were taken to represent different population densities. Richmond and Eastern Shore regions recorded the highest catch per unit

effort figures with all other areas being the same. Population densities were found to be low in most of the freshwater lakes but high in ri ers and estuaries.

3. Stocking of headwaters may result in increased populations of eels.

4. Populations of younger, larger eels were found to exist in the North Shore area. Richmond, South Shore, Eastern Shore and Southwestern Nova Scotia were found to have, in order, decreasing average sizes of eels and increasing average ages.

5. Values for pH in the northern end of the province were found to be substantially higher than those in the southern end of the province: pH = 7 and pH = 4.5, respectively. The more acid waters of Southwestern Nova may result in a decrease in food sources for eels as smaller organisms are adversely affected by such low pH.

6. Eels on the North Shore were found to have a high number of mummichogs in their stomachs. Yellow perch were common along the South Shore while gaspereau eggs were prevalent in Richmond County. Other areas were characterized by a range of food items, including the above mentioned. Eels were found to subsist on a diet of fish plus other organisms such as insects and shrimp.

7. Ageing techniques employed otoliths in an alizarine red dye and polarized light for observation. Results were accurate and the method allowed for a large number of otoliths to be examined.

8. Total mercury content for all eels in Nova Scotia was found to be 0.41 $\pm$ .01 ppm. The level is below the 0.50 ppm value set by Canadian-U.S. authorities as the allowable level for marketable fish.

Closing Remarks

Eel populations in Nova Scotia range in composition between areas. Demand for different sizes of eels by different markets insures that profitable fishing of all areas may be realized. In Holland, eels of an optimum size of 400 grams are desired, while in Belgium, requests are often made for sizes from 100 to 400 grams.

Populations in all areas of the province are strong enough to support increased fishing effort. A need for upper and lower size restrictions is essential, however, to insure the strength and ultimate longevity of the fishery stock. Based on population distributions and market demands, eels of under 50 grams and over 500 grams should be returned to the water within 24 hours of their capture. Eels of under 50 grams would be allowed to grow

into the size quota. Eels of over 500 grams would inevitably return to the sea to spawn.

Many areas of Nova Scotia are prime for the establishment of an integrated eel fishery. Cooperation between those interested in the eel fishery and export of the product will lead to higher profit margins as a result of larger shipments. Eel fishing is a young and viable industry in Nova Scotia and is open to the raw product market. Future operations may expand to include processing of smoked and jellied eel.

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